

AN EFFICIENT TECHNIQUE IN THE MINIMIZATION OF UNNECESSARY HANDOVER FOR MACRO-FEMTO CELLS IN LTE NETWORK

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Abstract

This paper presents an efficient technique in the reduction of frequent handover for macro-femto cells in Long Term Evolution (LTE) networks. A key design feature for handover decision algorithms is to guarantee seamless handover process between wireless access technologies without degrading the Quality of Service (QoS) and Quality of Experience (QoE) of the users. There are unwanted scenarios in vertical handover schemes where due to poor handover process, frequent handovers occur resulting in wastage of network resources, handover failures, and subsequent dissatisfaction of the users. Despite a number of efforts made to mitigate this problem of poor handover, network users still experience significant degradation in call quality owing to the dissimilarities in access technologies available and the changing speed of the user. A handover decision algorithm, which is based on the user's changing speed and network connection time, was proposed in this work and it involves the incorporation of a dwell time into a proximity model prediction technique in order to make the handover decision better. Results obtained using MATLAB R2015b version showed that the proposed algorithm attained a 77.46% reduction in the number of unnecessary handover.

Keywords: Long Term Evolution, Quality of Experience, Quality of Service, macrocell, femtocell, proximity model, handover, algorithm

1. Introduction

With the increase in demand for mobile data by cellular users alongside good signal quality for consumers, the need for the user to remain connected to the best available network even at indoor environments, has become an ongoing challenge for mobile operators to resolve Deswal and Singhrova, (2017). This rise in demand for mobile data has drawn the attention of researchers to this field to innovatively create network architectures that will expeditiously fulfill the demands of the user Andrews *et al.* (2012). To this end, macro-cellular networks have become overloaded in an attempt to provide for this astronomic growth in the number of users. To address this increasing demand from consumers, network service providers have to distribute femtocells side by side the conventional macro base station in order to boost capacity, thereby delivering better service coverage to the users Godor *et al.* (2015). Femtocells are normally operated at low transmit power of not more than 20dBm Xenakis *et al.* (2014). The transmit power specifies the area covered by the femtocell in terms of signal strength and this influences the handover process, interference, signaling, as well as the User Equipment (UE) service off rate Shbat and Tuzlukov, (2012).

1.1 Handover Procedure in Long Term Evolution

Handover procedures in LTE for user equipment in active mode are two types: the S1 and X2 handover procedures. Whilst the S1 handover procedure is carried out between two evolve Node Base stations (eNBs) without the X2 interface, the X2 is performed when there is direct connectivity

between the source and target eNBs Zavylova *et al.* (2016). The handover procedure commences with the reporting of the measurement of a handover event by the UE to a serving eNB. A downlink measurement reporting which is based on the Reference Symbols Received Power (RSRP) and the Reference Symbols Received Quality (RSRQ) is periodically carried out by the UE 3GPP. (2013). Based on the measurement reports from the UE, the serving eNB begins preparation for the handover Dimou *et al.* (2009). This preparation for the handover comprises of the exchange of signaling messages between the serving eNB and the target eNB alongside the admission control of the UE in the target base BS.

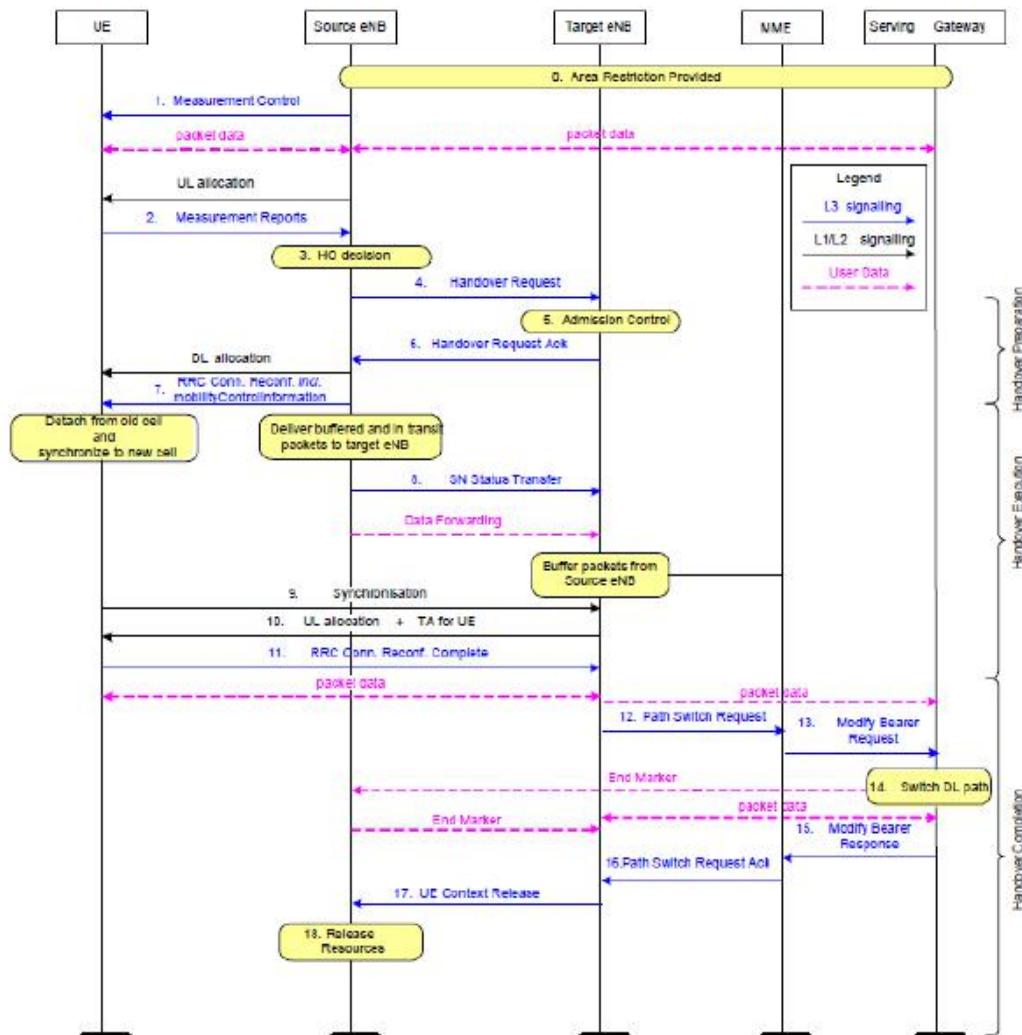


Figure 1: LTE Handover Procedure 3GPP. (2013)

2. Review of Related Work

Johnson *et al.* (2013) proposed a mathematical model based vertical handover prediction method consisting of a well-defined objective function that took into consideration Received Signal Strength (RSS), User Equipment (UE) velocity, load, and cost per user bandwidth. The setback in this work was that the authors did not consider the scenario where the UE speed changed as a result of the UE's unpredictable behavior thereby degrading the user's QoS in terms of throughput. Mutlu and

Canberk. (2014) proposed a handover decision algorithm in which, measurement of the path loss and spatially approximated path loss of future location formed the basis for the model. The pitfall of the work was the delay that could arise due to the increase in the time-to-trigger (TTT), resulting to call drop and subsequent dissatisfaction of the users. Hoang *et al.* (2014) proposed a cell selection technique for inter-femtocell handover that minimized unnecessary handovers and bolstered the quality of communication link of the user by not allowing handover to be made to an overloaded target cell. The drawback in the algorithm was that the authors did not consider the delay arising from the algorithm which could result in the time-to-trigger being increased. Rajabizadeh and Abouei. (2015) proposed a handover decision algorithm for inter-femtocells based on the received signal strength and the velocity of the user. The problem of interference that could occur due to the signal from a farther cell overlapping with an adjacent cell was not considered by the authors. This could negatively affect the results obtained. Ben Cheikh *et al.* (2015) proposed a handover decision algorithm which utilized mobility prediction that is derived from the Hidden Markov Model (HMM). The mobility prediction technique was based on the quality of signal of the candidate cells for handover, and the historical and current movement information of the UE. However, the problem of this algorithm is that the mobility prediction would not be able to cater for a new user since it does not have the historical information of the user. Deswal and Singhrova. (2017) proposed a handover decision algorithm for an integrated macrocell and femtocell network in which the macrocell network was overlayed by several femtocell networks using equivalent received signal strength (RSS_{eq}) and a dynamic hysteresis margin. The major problem of the work was that the changing speeds of the UV, which was due to the unpredictable movement pattern of the users were not considered as input parameters for deciding where and when to perform the handover, since both cells have dissimilar wireless access technologies. This could lead to degradation in quality of service. However with the incorporation of a dwell timer into the proximity model prediction technique, its effect would result in an improved performance in terms of the quality of service on offer.

3. Improved Algorithm: DVHA (Developed Vertical Handover Algorithm)

To address the issue of unnecessary handover especially as the user speed changes, a mobility prediction technique that considers the changing speed of the user is presented. The following steps were used in the development of the DVHA.

1. For simulation purpose, an LTE macrocell-femtocell network architecture made up of one macrocell and 60 femtocells was used.
2. The Received Signal Strength (RSS) of macrocell and femtocell at all UV positions was obtained.
3. Random movement mobility model to model the movement pattern of the UV at varying speed was obtained.
4. Path loss between the UV and the femtocell access point was generated. The proximity prediction technique was used to mitigate the occurrence of packet losses during the handover process.
5. The probability of unnecessary handover occurring was then calculated using Eqn (1)
Thursday Ehis, (2014)

$$P_u = \left[\int_{-\infty}^{\infty} f(x) \left(\frac{1}{2} \operatorname{erf} \left(x - \frac{h-\Delta l}{\delta} \right) \right) dx \right] \left[\int_{-\infty}^{\infty} f(x) \left(\frac{1}{2} \operatorname{erf} \left(x - \frac{h+\Delta l}{\delta} \right) \right) dx \right] \quad (1)$$

The equation used to describe the rate of handover during the packet delivery process was given as Eqn (2) Singh et al. (2005)

$$\lambda_H(h) = \frac{KD}{320} \left(1 - \exp \left(-\frac{b}{h^a} \right) \right) \quad (2)$$

The total link availability of the Proximity model was given as Eqn (3) (McDonald and Znati. (1999)
 $A_{m,n}^T(t) = [A_{m,n}^i(t)] \quad (3)$

4. Simulation Environment

MATLAB R2015b version was used in the simulation of this work. MATLAB R2015b was used to compare the performance of the DVHA and the Existing Vertical Handover Algorithm (EVHA). The simulation parameters used in this work are as shown in Table 1. Furthermore; Figure 2, figure 3 and figure 4 shows the flowchart of the DVHA when the users were connected to macrocell, the flowchart of the DVHA when the users were connected to the femtocell and the MATLAB code used to design the EVHA and the DVHA respectively.

Table 1 Simulation Parameters Used in this Work

Parameter	Macrocell	Femtocell
Radius	1 Km	30 m
Transmission Power	43 dBm	20 dBm
Threshold Power	NA	-80 dBm
Path Loss Model	$128.1 + (37.6 * \log_{10}(\text{distance} * 0.001))$	$A * \log_{10}(\text{distance}) + B + C \log_{10}(f_c / 5)$
Bandwidth	20 MHz	20 MHz
Number of Cells	1	60
Number of Users	10-50	10-50
Simulation Time	120	120

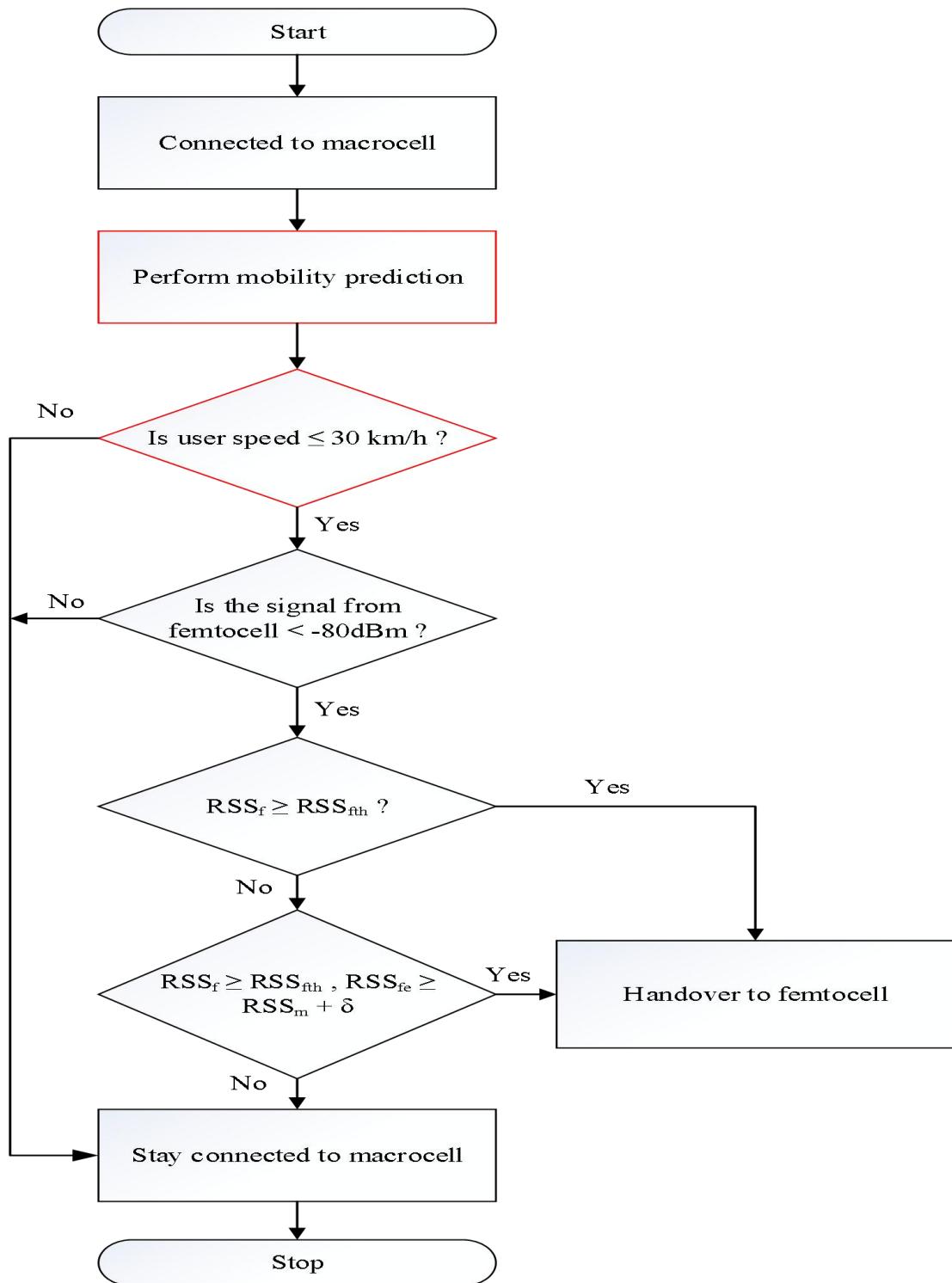


Figure 2: Flowchart of DVHA when Users were connected to Macrocell

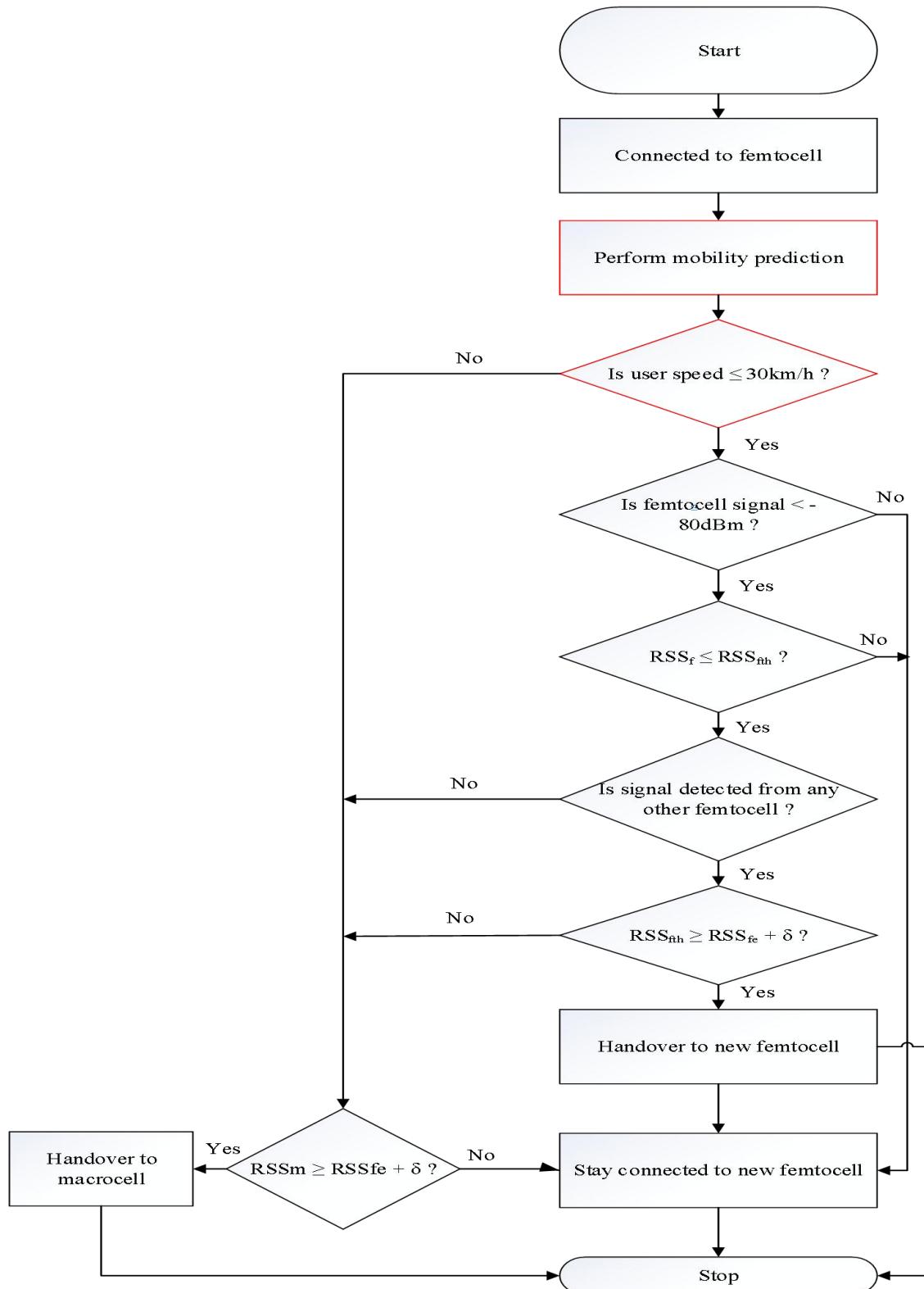


Figure 3: Flowchart of DVHA when Users were connected to Femtocell

```

function users = hoAlgo2(mCell, fCell, users)
%clc
%load users
%load fCell
%load mCell
A = 20; B = 46.4; C = 20; % for LOS transmission
% A = 18.7; B = 46.4; C = 20; % for NLOS transmission
fc = 20;
txM = 43;
txF = 20;
rssFth = -80;

for u = 1:numel(users)
    %calculate the distance and RSS of femtocells
    distF = arrayfun(@(f) norm(f.pos - users(u).pos), fCell)/1000;
    pIF = A.*log10(distF) + B + C.* log10(fc/5);
    % pIF = A.*log10(distF) + B + C.* log10(distF/0.03);
    % pIF = 38.46 + 20*log10(distF);
    rssF = txF - pIF;

    % [rMax, ind]=max(rssF);
    % distF(ind)*1000
    % r31 = rssF(31)
    %calculate the distance and RSS of macrocell
    distM = norm(mCell.pos - users(u).pos)/1000;
    pIM = 128.1 + (37.6.*log10(distM *0.001));
    rssM = txM - pIM;
    %equivalent RSS of femto cell
    d = arrayfun(@(f) norm(f.pos - mCell.pos), fCell);
    NTx = (txM-txF)/(txF+txM);
    rssFE = rssF + (NTx./d).*rssM;
    % max(rssFE)

    % handover margin
    if users(u).cellID == 0
        sCell = mCell;
        delMax = 124.1187;
    else
        sCell = fCell(users(u).cellID);
        delMax = 35.5630;
    end
    distance = norm(sCell.pos - users(u).pos);
    radius = sCell.r;

```

Figure 4: MATLAB Code Designing the EVHA and the DVHA

5. Results and Discussion

Figure 5 shows the result of the performance of EVHA and DVHA. The unnecessary handover was calculated using equation 1. A Markovian model for random motion was used for the network simulation. From the plot, it can be observed that the developed vertical handover scheme displayed less number of handover when compared to the existing vertical handover scheme. This was achieved as a result of the effect of the mobility prediction scheme deployed, as well as the dwell time that was incorporated. Furthermore, the fluctuations as evident in the plot are due to the varying speed of the users as they move towards either the femtocell or macrocell. Equation (4) shows the mathematical expression for obtaining the percentage reduction in unnecessary handover from the plot shown in figure 5

$$\text{Percentage Reduction} = \frac{\sum \text{EVHA} - \sum \text{DVHA}}{\sum \text{EVHA}} \times 100 \quad (4)$$

Table 2: Number of Users and Number of Unnecessary Handovers

Number of Users	Number of Handover for EVHA	Number of Handover for DVHA	Number of Unnecessary Handovers
10	50	13	37
20	105	23	82
30	150	32	118
40	213	49	164
50	263	59	204

The data in table 2 were obtained through MATLAB simulation using MATLAB R2015b version. In the simulation 60 femtocells were deployed on the macrocell with the number of users set at 10,20,30,40 and 50 respectively; whilst setting the speed of the users within the range of 30 to 120km/h at a simulation time of 120 seconds.

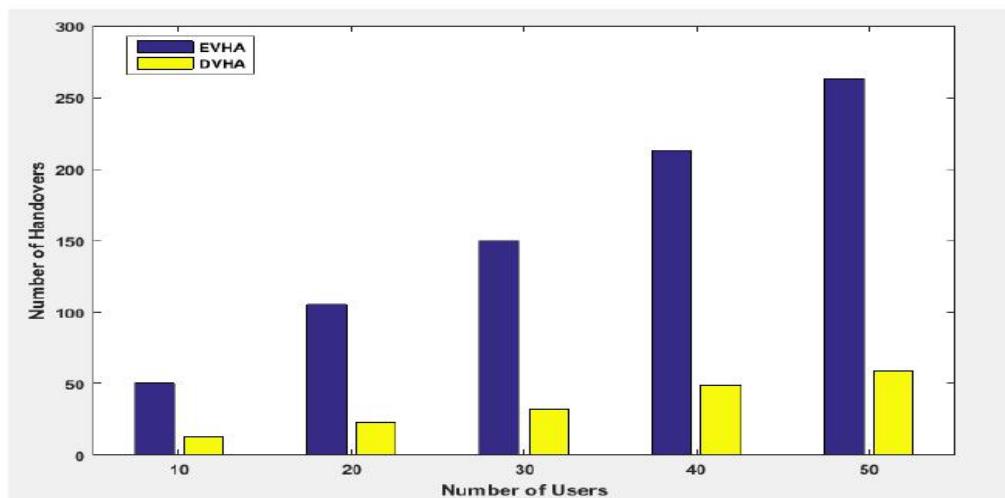


Figure 5: Plot of Number of Handovers to Number of Users

Figure 5 shows the plot obtained from the values in table 2 during the simulation run. From the plot, it can be observed that the improved vertical handover decision scheme performed fewer handovers when compared to the existing vertical handover decision scheme. This was achieved as the number of users increased. The improved vertical handover decision algorithm extends the network connection time (dwell time) within which users should spend on either cell, thus reducing the number of handovers. Furthermore, as can be observed from the plot, there is a corresponding increase in the number of handovers as the number of users' increases. This is because handovers occur more frequently as the number of users' increases due to the increasing speed of the UV.

6. Conclusion

From the discussed results, it can be seen that the developed vertical handover decision algorithm successfully improved the performance of the existing vertical handover decision algorithm. The developed vertical handover decision algorithm performed better than the existing vertical handover decision algorithm in terms of number of unnecessary handovers. The developed vertical handover decision algorithm achieved a 77.46% reduction in the number of unnecessary handovers when compared to the existing vertical handover decision algorithm. This reduction in the number of unnecessary handover was achieved by incorporating a dwell time into a mobility prediction technique to enhance the handover decision.

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